Early Birds and Night Owls: Distinguishing Profiles of Cannabis Use Habits by Use Times with Latent Class Analysis

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ABSTRACT

Background: Understanding, predicting, and reducing the harms associated with cannabis use is an important field of study. Timing (i.e., hour of day and day of week) of substance use is an established risk factor of severity of dependence. However, there has been little attention paid to morning use of cannabis and its associations with negative consequences. **Objectives:** The goal of the present study was to examine whether distinct classifications of cannabis use habits exist based on timing, and whether these classifications differ on cannabis use indicators, motives for using cannabis, use of protective behavioral strategies, and cannabis-related negative outcomes. **Methods**: Latent class analyses were conducted on four independent samples of college student cannabis users (Project MOST 1, N=2,056; Project MOST 2, N=1846; Project PSST, N=1,971; Project CABS, N=1,122). **Results**: Results determined that a 5-class solution best fit the data within each independent sample consisting of the classes: (1) "Daily-morning use", (2) "Daily-non-morning use", (3) "Weekend-morning use", (4) "Weekend-night use", and (5) "Weekend-evening use." Classes endorsing daily and/or morning use reported greater use, negative consequences and motives, while those endorsing weekend and/or non-morning use reported the most adaptive outcomes (i.e., reduced frequency/quantity of use, fewer consequences experienced, and fewer cannabis use disorder symptoms endorsed). **Conclusions**: Recreational daily use as well as morning use may be associated with greater negative consequences, and there is evidence that most college students who use cannabis do avoid these types of use. The results of the present study offer evidence that timing of cannabis use may be a pertinent factor in determining harms associated with use.

Key words: = cannabis use; weekend; weekday; morning; night; time of use; cannabis motives

Negative consequences associated with cannabis misuse are of primary concern to cannabis researchers (Pearson, 2019). There is evidence that cannabis-related negative consequences may include mental health concerns such as psychosis (D'Souza et al., 2016; McHugh et al., 2017), depression and suicidality (Kimbrel et al., 2018; Roberts, 2019), impacts on cognitive function and educational achievement (Arria et al., 2015; Homel et al., 2014; Meier et al., 2012), motor vehicle accidents (National Academies of Sciences, Engineering, and Medicine, 2017), and increased

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risk for developing prescription opioid use disorders (Olfson et al., 2018), among others. A variety of risk and protective factors are associated with cannabis-related consequences, including characteristics of the individual using cannabis, the products they are using, and patterns of consumption. These may include an individual's use of protective behavioral strategies (Bravo, Anthenien et al., 2017), the frequency (Looby & Earleywine, 2007), quantity (Walden & Earleywine, 2008; Zeisser et al., 2012), and potency (Prince & Conner, 2019) of cannabis consumed, as well as the timing of use, both over the course of a week (i.e., weekend vs. weekday use; Bravo, Pearson et al., 2017; Buckner et al., 2019) and over the course of a single day (Earleywine et al., 2016).

Of these constructs, timing of use has received little empirical attention as a factor associated with cannabis use and related consequences, despite research that supports its relevance. With regard to timing of use over the course of a week, one daily diary study conducted among cannabis using college students found that they reported significantly greater cannabis use on weekend days compared to weekdays (Bravo, Pearson et al., 2017). Another study found that the influence of cannabis motives on use and related problems were distinct based on whether the motives were related to weekend or weekday use (Buckner et al., 2019). Specifically, all 5 motives (social, coping, enhancement, conformity, and expansion; Simons et al., 1998) for using cannabis on the weekdays, as well as enhancement and conformity motives for weekend use, were significantly positively associated with greater cannabis use frequency. With regard to cannabis related problems, all 5 motives for using cannabis on weekends, as well as expansion motives for weekday use, were associated with more problems experienced (Buckner et al., 2019).

Timing of use over the hours of a single day has received even less research attention than weekend vs. weekday use. It is plausible that the acute subjective and cognitive effects of any intoxicant, when consumed earlier in the day, may alter mood, judgment, and decision making such that the experience of negative consequences becomes more likely. In the alcohol literature, an "eye-opener" is an alcoholic drink consumed early in the day and is often interpreted as an attempt to relieve withdrawal (Earleywine et al., 2016). Questions on consumption of "eye-openers" are commonly deployed in clinical instruments designed to identify problem drinking (e.g., CAGE, Beresford et al., 1990; TWEAK, Cherpitel, 1999; T-ACE, Sokol et al., 1989). Similarly, the first item on the most used measure for nicotine dependence asks, "How soon after you wake up do you smoke your first cigarette?" (Fagerstrom Test for Nicotine Dependence, FTND; Heatherton et al., 1991). These examples clearly highlight that morning use of alcohol and cigarettes is associated with clinical problems, though the processes by which this occurs are thought to be complex (Epler et al., 2014).

Alternatively, "wake and bake" is a colloquial term that refers to morning cannabis use and is integrated in the cannabis subculture, though "wake and bake" is discouraged by individuals who have been using cannabis for a long time (Lau et al., 2015). Morning cannabis use may be attributed to a number of psychological factors, including mood. Testa and colleagues (2019) identified increased daily cannabis use among participants reporting lower positive affect (relative to their own norms) in the morning time. Additionally, in one of the few studies to directly examine morning use of cannabis, Earleywine and colleagues (2016) compared 257 college students who reported using daily before noon on all 7 days of a week to 76 participants who also used daily but reported never using before noon. The researchers found that morning use accounted for a unique portion of the variance in cannabis-associated problems when controlling for quantity of cannabis consumed, age, and gender, thus supporting morning use as an indicator of more problematic use. These findings suggest time of use may be associated with increased cannabis-related impairment, problems, and dependence.

While current evidence on the relationship between morning cannabis use and related problems is not causal, previous studies indicate heavier cannabis use may be associated with more problems associated with dependence. For example, participants in a clinical trial reported decreases in subjective intoxication ratings after using cannabis on 4 consecutive days in accordance with patterns of increased tolerance (Gorelick et al, 2013). Understanding the association between timing of cannabis use patterns, dependence, and related consequences may yield insight toward preventing harmful use.

Purpose of the Present Study

The present study aimed to examine whether distinct patterns of cannabis use exist based on timing of use (i.e., hour of day and day of week) using latent class analysis (LCA). We also sought to examine whether latent classes differed on cannabis use indicators, motives for using cannabis, and cannabis-related negative outcomes. Given the exploratory nature of LCA, we conducted our analyses across four independent samples of young adult cannabis users to examine replicability. We hypothesized that a LCA based on timing of cannabis use would produce groups that differ on weekend vs. weekday and morning vs. non-morning use. We also expected that classes characterized by morning use and more frequent use (i.e., number of days) would report overall greater levels of cannabis use, motives for using cannabis, and number of negative cannabis-related consequences.

METHODS

Participants and Procedures

The present study is a secondary data analysis of four independent studies (Projects MOST 1, MOST 2, PSST, and CABS) focused on substance use and mental health among college students. Detailed descriptions of study participants and procedures for the parent studies are found in prior published studies (Project MOST [Marijuana Outcomes Study Team] 1, Pearson, Liese, et al., 2017; Project MOST 2, Richards et al., 2021; Project PSST [Protective Strategies Study Team], Bravo et al., 2018; Project CABS [Cross-Cultural Addictive Behaviors Study], Bravo et al., 2021). All data were collected cross-sectionally among college students recruited from participating institution's Psychology department participant pools, based on retrospective self-report surveys. The analytic samples of the present study were limited to U.S. college students who reported past month cannabis use and completed our primary measure of cannabis use (Project MOST 1, N = 2,056, 59.5% female; Project MOST 2, N = 1,846, 60.8% female; Project PSST, N = 1,971, 68.2% female; Project CABS, N = 1,122, 66.3% female).

Measures

Cannabis Use Time Indicators for LCA

Across all four samples, cannabis use times was assessed using the Marijuana Use Grid (MUG; Pearson, Marijuana Outcomes Study Team, & Protective Strategies Study Team, 2022). As done in prior studies utilizing the MUG (e.g., Bravo et al., 2021; Pearson, Kholodkov, et al., 2017), a table was created such that each day of the week (columns) was broken down into six 4-hour time blocks (rows; 12a-4a, 4a-8a, 8a-12p, etc.), and participants were asked "During a week of typical marijuana use in the past 30 days, please indicate times, days, and approximate number of grams of marijuana that you used". Participants were provided with images of varying amounts of cannabis to facilitate accurate estimates of their quantity of use in terms of grams of flower. Participants wrote into each cell of the table approximately how many grams of cannabis they used (if applicable). For the present study, we coded whether each participant endorsed using cannabis on a specific day regardless of time block (e.g., if a participant endorsed use on Monday [at any time block] they were coded as a "1" for Monday use) and specific time block regardless of day of use (e.g., if a student endorsed use during 4a – 8a time block [regardless of what day of the week] they were coded as a "1" for 4a – 8a use). Taken together, 13 (7 days of week and 6 time blocks) dichotomous variables (0 = no use, 1 = use) were utilized as indicators in the LCAs.

Auxiliary Outcome Variables

All measures used have been validated among college student samples and prior published studies using these datasets have found good internal consistency for each measure among marijuana users within each dataset.

Cannabis use. Typical use frequency and quantity were assessed using the MUG (Pearson, Marijuana Outcomes Study Team, & Protective Strategies Study Team 2022). In addition to asking which times participants used, they were also asked to report the quantity of grams of flower consumed during each time block they had used within. We calculated typical frequency of cannabis use by summing the total number of time blocks for which participants reported using during the typical week (possible range = 0-42). Typical quantity of cannabis use was calculated by summing the total number of grams consumed across time blocks during the typical week. This measure was collected in all datasets.

Cannabis motives. Cannabis use motives were measured with the Marijuana Motives Questionnaire Short Form (MMQ-SF; Simons et al., 1998). This 24-item scale uses a 5-factor model for measuring motives for using cannabis on the dimensions of enhancement (3 items), conformity (3 items), expansion (3 items), coping (3 items) and social (3 items) motives. Participants respond on a 5-point scale from 1 = *Almost never/never* to 5 = *Almost always/always*. For each motive, items were averaged such that higher scores are associated with higher endorsement of that motive. This measure was collected in all datasets.

Cannabis-related problems and misuse. Past 30-day cannabis-related problems were assessed using the 21-item Brief Marijuana Consequences Questionnaire (B-MACQ; Simons et al., 2012) in MOST2, PSST, and CABS datasets, and the longer 50-item version was used in the MOST1 dataset. We summed all items to create a cannabis-problems composite score characterized by the number of distinct problems experienced in the past 30 days. Cannabis use disorder (CUD) symptoms were assessed using the 8-item Cannabis Use Disorders Identification Test-Revised (CUDIT-R; Adamson et al., 2010). Items were summed to create a total score with greater scores indicating greater misuse of cannabis. This measure was collected in all datasets except Project MOST 1.

Cannabis use norms. A 9-item scale for assessing injunctive norms related to cannabis use (Montes et al., 2021) was employed to examine participants' perceptions of others' approval of behaviors related to use (i.e., using cannabis, using to get high, using daily). Participants responded on a 7-point scale (1 = *Strongly disapproving* to 7 = *Strongly approving*) and were asked about three different groups: their best friends, the typical college student, and their parents. This measure was only collected in Projects MOST 1 and MOST 2.

Cannabis internalized norms. Internalized norms related to college cannabis use was assessed using the Perceived Importance of Marijuana to the College Experience (PIMCES; Pearson, Kholodkov, et al., 2017). This scale measures internalized norms related to college cannabis use and has been validated in college student populations. The measure includes 13 items (e.g., "*To get high on marijuana is a college rite of passage*") and participants respond on a 5-point scale from 1 = *Strongly disagree* to 5 = *Strongly agree*. This measure was only collected for Projects MOST 1 and PSST.

Cannabis Protective Behavioral Strategies. Cannabis protective behavioral strategies were assessed using the Protective Behavioral Strategies for Marijuana (PBSM; Pedersen et al., 2016; 2017). Two versions of this measure exist, the 50-item version (used in MOST 1 dataset; Pedersen et al., 2016) and the 17-item version (used in MOST 2 and PSST datasets; Pedersen et al., 2017). This scale measures participant's use of behavioral strategies for mitigating the negative impacts of cannabis use. These strategies include things like limiting use, reducing the likelihood that others would know they used, and reducing the likelihood of experiencing legal problems. Participants were asked to report how often they used specific strategies on a scale from 1 = *Never* to 6 = *Always*. This measure was collected in all datasets except Project CABS.

Cannabis Identity. Identification with being an individual who uses cannabis was examined with a 5-item scale modified from the Smoker Self Concept Scale (Shadel & Mermelstein, 1996). Participants rated each item from 1 = *Strongly disagree* to 7 = *Strongly agree* on statements about how much cannabis plays a role in their life and personality, as well as others' perceptions about the role of cannabis in their life (for example, "*Marijuana is a part of 'who I am'*"). This measure was only collected in Projects MOST 1 and MOST 2.

Statistical Analyses

To test study aims, we conducted independent LCAs based on cannabis use timing indicators on the four independent samples using *Mplus* 8.3 (Muthén & Muthén 1998 - 2019). In all four datasets, to determine the optimal class solution, we examined goodness-of-fit indices (e.g., sample adjusted Bayesian Information Criterion; Sclove, 1987; Akaike Information Criterion; Akaike 1973, 1974), classification diagnostics (e.g., relative entropy), and the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LRT; Lo et al., 2001; Vuong, 1989). Moreover, we substantively interpreted the class solutions and adopted advice from Nagin (2005) suggesting that if it is difficult to identify the optimal number of latent classes (for example, if the LRT, goodness-of-fit indices and classification diagnostics provide an ambiguous optimal class solution), the most parsimonious class solution that contains a smallest class greater than 5% of the total analytic sample should be selected. After determining the optimal number of latent classes, equality of weighted means on the auxiliary outcome variables were tested across classes using the automatic BCH method (Asparouhov & Muthén 2015; Bakk & Vermunt 2016), which utilizes posterior probability-based multiple imputations (Asparouhov & Muthén 2007).

RESULTS

Table 1 reports commonly utilized fit statistics for each sample on 1 through 7 class solutions. Across each sample, the LRT suggests that a higher class solution fit better than the previous class solution (e.g., 5-class solution fit significantly better than a 4-class solution). Although the 6- and 7-class solutions did fit significantly better than their k-1 class comparisons on the LRT, AIC, BIC, and adjusted BIC, the smallest class sizes for 2 of 4 datasets fell below 5% of the total analytic sample for each class solution above 5. For the 5-class solution found in the CABS dataset, though the smallest class size was 4.3% of the total analytic sample from that dataset, in each other sample the smallest class size remained above 5%. Further, the relative entropy for the 5-class solutions across samples was above 0.85 (above 0.90 in 2 of 4 datasets), which is considered excellent classification quality (>0.80 is considered 'high'; Clark & Muthén, 2009). Therefore, after examining each of these results in concert with substantive theoretical interpretation of the classes (Marsh et al. 2009; Nylund et al. 2007), we selected the 5-class solutions as best fitting the data across samples.

The overall pattern of cannabis use endorsed was generally consistent across all four independent samples. This occurred such that, across all samples and classes, participants endorsed using: 1) at similar levels from Sunday-Thursday (range across datasets = 36.6-46.3%), 2) more on Fridays and Saturdays (range across datasets = 70.4-79.5%), 3) the least between 4am-8am (range across datasets = 6.8-8.0%), and 4) at progressively greater rates as the typical day progressed (8am-12pm range across datasets = 17.6-21.5%; 12pm-4pm range across datasets = 25.2-26.2%; 4pm-8pm range across datasets = 39.9-48.1%; 8pm-12am range across datasets = 77.1-82.4%), until the 12am-4am time block where use endorsement dropped (range across datasets = 22.0-31.6%; see Figure 1). The 5 classes (see Figure 2 and Table 2) identified were also similar across the four independent samples and were characterized by 2 daily use classes (classes 1 and 2) and 3 weekend use classes (classes 3-5) of varying qualities. Class 1 is referred to as the *daily-morning class* because individuals in this class were characterized by daily and common morning use (i.e., 8am-12pm). Class 2 is referred to as the *daily-non-morning class* as individuals in this class were characterized by daily and uncommon use between 8am-12pm. Class 3 is referred to as the *weekend-morning class* as individuals in this class were characterized by mostly weekend (i.e., Friday and Saturday) and common morning use. Class 4 is referred to as the *weekend-night class* because individuals in this class were characterized by weekend use, uncommon morning use, and common nighttime use (i.e., 8pm-12am). Class 5 is referred to as the *weekend-evening class* as individuals in this class were characterized by weekend use, and common use from 4-8pm but were the only class to endorse a decrease in use from 8pm-12am (in 3 of 4 datasets, use from 8pm-12am was zero for this class). Among the MOST 1, MOST 2, and PSST samples, class 4 was the largest class, while in the CABS sample class 5 was the largest class.

The daily use classes 1 and 2 similarly endorsed using around 90% of the time or greater on every day of the week (*daily-morning*, class 1: range across datasets = 96-100%, mean across datasets = 99.0%; *daily-non-morning*, class 2: range across datasets = 89.1-100%; mean across datasets = 96.5%) but diverged in their endorsement of morning use between 8am-12pm (*daily-morning*, class 1: range across datasets = 78.6-84.2%, mean across datasets = 81.6%; *daily-non-morning*, class 2: range across datasets = 13.3-18.5%; mean across datasets = 16.1%). For the three weekend classes, they endorsed using around 40-90% of the time on

Table 1. *Fit Statistics for 1 Through 7 Class Solutions for Latent Class Analysis (LCA) Across Four Independent Samples*

	Number of Classes						
MOST1	1	2	3	4	5	6	7
AIC	30797.245	25081.738	24572.775	24871.021	23834.567	23589.674	23370.512
BIC	30870.416	25233.708	24803.545	24491.589	24222.935	24056.841	23916.478
Sample-Size Adjusted BIC	30829.144	25147.927	24673.284	24316.850	24003.716	23793.143	23608.302
Lo-Mendell Rubin LRT p-value	---	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Relative Entropy	---	0.953	.822	.924	.910	.900	.851
Smallest n (% of total sample)	2056	608.6 (29.6%)	576.6 (28.0%)	227.7. (11.1%)	207.0 (10.1%)	40.6 (2.0%)	41.1 (2.0%)
MOST2	1	2	3	4	5	6	7
AIC	28454.593	22947.702	22516.415	22184.800	21878.992	21672.366	21559.231
BIC	28526.363	23096.763	22742.767	22488.443	22259.926	22130.590	22094.746
Sample-Size Adjusted BIC	28485.063	23010.984	22612.511	22313.709	22040.715	21866.901	21786.580
Lo-Mendell Rubin LRT p-value	---	<.0001	<.0001	0.0489	<.0001	<.0001	.0008
Relative Entropy	---	.963	.836	.915	.903	.916	.863
Smallest n (% of total sample)	1846	557.8 (30.2%)	541.9 (29.4%)	230.0 (12.5%)	206.5 (11.2%)	151.9 (8.2%)	152.5 (8.3%)
PSST	1	2	3	4	5	6	7
AIC	29860.983	23345.254	22888.611	22502.494	22236.757	22029.845	21870.633
BIC	29933.605	23496.084	23117.649	22809.741	22622.212	22493.507	22412.504
Sample-Size Adjusted BIC	29892.303	23410.304	22987.390	22635.004	22402.996	22229.813	22104.331
Lo-Mendell Rubin LRT p-value	---	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Relative Entropy	---	.971	.930	.853	.884	.890	.906
Smallest n (% of total sample)	1971	629.0 (31.9%)	317.3 (16.1%)	289.1 (14.7%)	292.5 (14.8%)	142.9 (7.3%)	132.6 (6.7%)
CABS	1	2	3	4	5	6	7
AIC	16960.277	13585.165	13263.116	13039.313	12861.730	12737.292	13794.691
BIC	17025.574	13720.782	13469.054	13315.571	13208.308	13154.191	14296.193
Sample-Size Adjusted BIC	16984.283	13635.023	13338.827	13140.76	12989.145	12890.560	13988.071
Lo-Mendell Rubin LRT p-value	-----	< .0001	0.0037	.0048	< .0001	<0.0024	0.0006
Relative Entropy	-----	.953	.854	.905	.853	.845	.870
Smallest n (% of total sample)	1122	384.4 (34.3%)	209.5 (18.7%)	72.2 (6.4%)	50.1 (4.3%)	34.3 (3.1%)	34.1 (2.6%)

Note. AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion. LRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test.

Table 2. *Description of the 5 Classes Found in LCA Analyses Across 4 Independent Samples*

Class #	Class Title	% of total sample for each dataset	Class Description
1	Daily, morning use	MOST 1: 10.4% of the total sample MOST 2: 14.5% of the total sample PSST: 16.4% of the total sample CABS: 12.5% of total sample	Across each of the four samples, these classes displayed 96% or greater endorsement of use on each day of the week, as well as 78.6% or greater endorsement of use between the times of 8am-12pm. These classes showed the lowest endorsement of use during the time period of 4am-8am (32.9% or lower) and the greatest endorsement of use between the times of 4pm-8pm and 8pm-12am (93.4% or greater).
2	Daily, non-morning use	MOST 1: 16.1% of the total sample MOST 2: 13.1% of the total sample PSST: 14.4% of the total sample CABS: 22.7% of total sample	Across each of the four samples, these classes exhibited 88.3% or greater endorsement of use on each day of the week, and 18.5% or less endorsement of use between the times of 8am-12pm. These classes showed the lowest endorsement of use during the period of 4am-8am (3.7% or lower) and the greatest endorsement of use during the period of 8pm-12am (76.3% or greater).
3	Weekend, morning use	MOST 1: 9.2% of the total sample MOST 2: 10.0% of the total sample PSST: 13.2% of the total sample CABS: 4.5% of total sample	Across each of the four samples, these classes displayed 69.2% or greater endorsement of use on both Friday and Saturday, while on the remaining days of the week endorsed 55.4% or less use. In 3 out of 4 samples, this class showed 40.1% or greater endorsement of use between the times of 8am-12pm (for the PSST sample, 24.9% endorsed use from 8am-12pm). These classes showed the lowest endorsement of use during the time period of 4am-8am (66.9% for CABS sample, 24.2% or lower for all other samples) and the greatest endorsement of use during the period of 8pm-12am (78.2% or greater).
4	Weekend, night use	MOST 1: 49.7% of the total sample MOST 2: 44.2% of the total sample PSST: 40.7% of the total sample CABS: 28.2% of total sample	Across each of the four samples, these classes showed 56.7% or greater endorsement of use on both Friday and Saturday, while on the remaining days of the week endorsed 19.9% or less use. These class 4 or "Weekend, night use" classes endorsed using less than all other classes in their respective samples for the time blocks 12am-4am, 4am-8am, 8am-12pm, and 4pm-8pm (17.5% or less for all samples), while also showing the greatest endorsement of use compared to all other classes in their respective samples in the time block 8pm-12am (100% endorsement for all samples). The lowest endorsement of use within this class was during the time period 4am-8am (0% in all samples).
5	Weekend, evening use	MOST 1: 14.6% of the total sample MOST 2: 18.1% of the total sample PSST: 15.3% of the total sample CABS: 34.0% of total sample	Finally, in 3 out of 4 (MOST 1, MOST 2, and PSST) samples, these classes exhibited 41.7% or greater endorsement of use on both Friday and Saturday, while on the remaining days of the week endorsed 16.7% or less use. Still in 3 out of 4 samples, these "Weekend, evening use" classes endorsed a marked decrease in use in the time block 8pm-12am (0% endorsed use in the 3 samples) when compared to 4pm-8pm (between 57.2% and 35.8% endorsed use in the 3 samples). In the CABS sample, this class displayed similar patterns when compared to the other 3 samples, with some key differences. These are, for each day of the week, class 5 in the CABS sample showed greater levels of use than class 4, and the decrease in endorsed use from 4pm-8pm (60.2%) to 8pm-12am (55.2%) was far less pronounced in contrast to the other samples. Though these differences existed among the CABS sample compared to the other 3, the overall pattern observed is the same. The class 5 or "Weekend, evening use" class in CABS also endorsed using on Friday and Saturday (65.3%) greater than the remaining days of the week (30.8%), and showed a slight decrease in use endorsed between the evening (4pm-8pm) and nighttime (8pm-12am) time blocks.

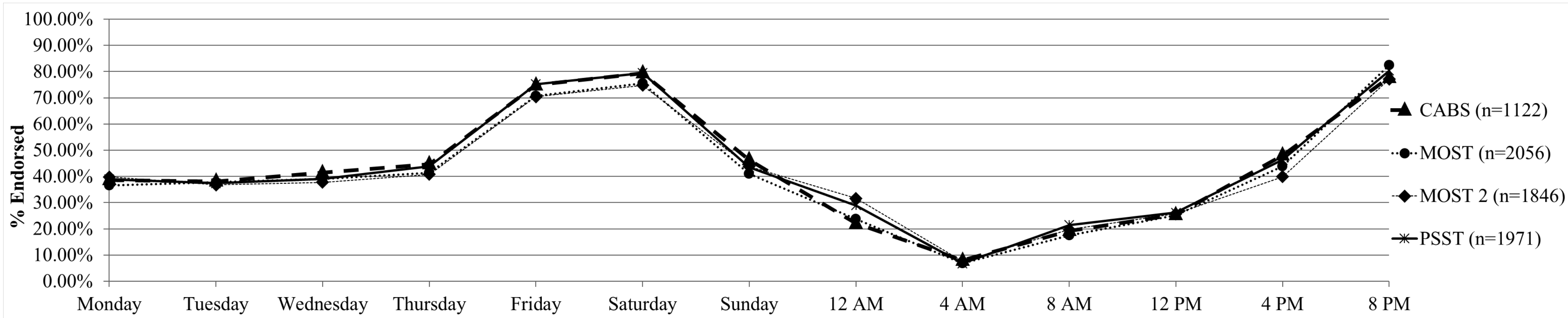

Figure 1. Depiction of endorsement rates of cannabis use times across the four independent samples. Note that days of the week and times of day are dichotomized variables, thus values are interpreted as the percentage of the sample that endorsed using marijuana on a particular day and at specific times over the course of a day (in terms of six 4-hour blocks of time).

Project MOST 1

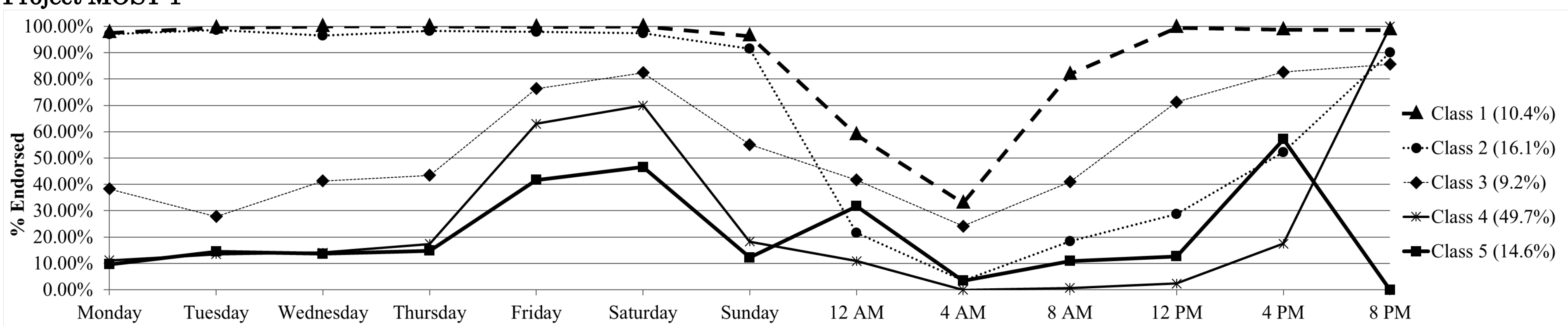

Figure 2. Depiction of the five latent classes defined by the percent likelihood that a participant assigned to a class endorsed using cannabis on each day of a typical week and at specific times over the course of a day (in terms of six 4-hour blocks of time) across four independent samples. Note that days of the week and times of day are dichotomized variables, thus values are interpreted as the percentage of each class that endorsed using marijuana on a particular day and at specific times over the course of a day. Class 1 = *Daily, morning use*; Class 2 = *Daily, non-morning use*; Class 3 = *Weekend, morning use*; Class 4 = *Weekend, evening use*; Class 5 = *Weekend, afternoon use*.

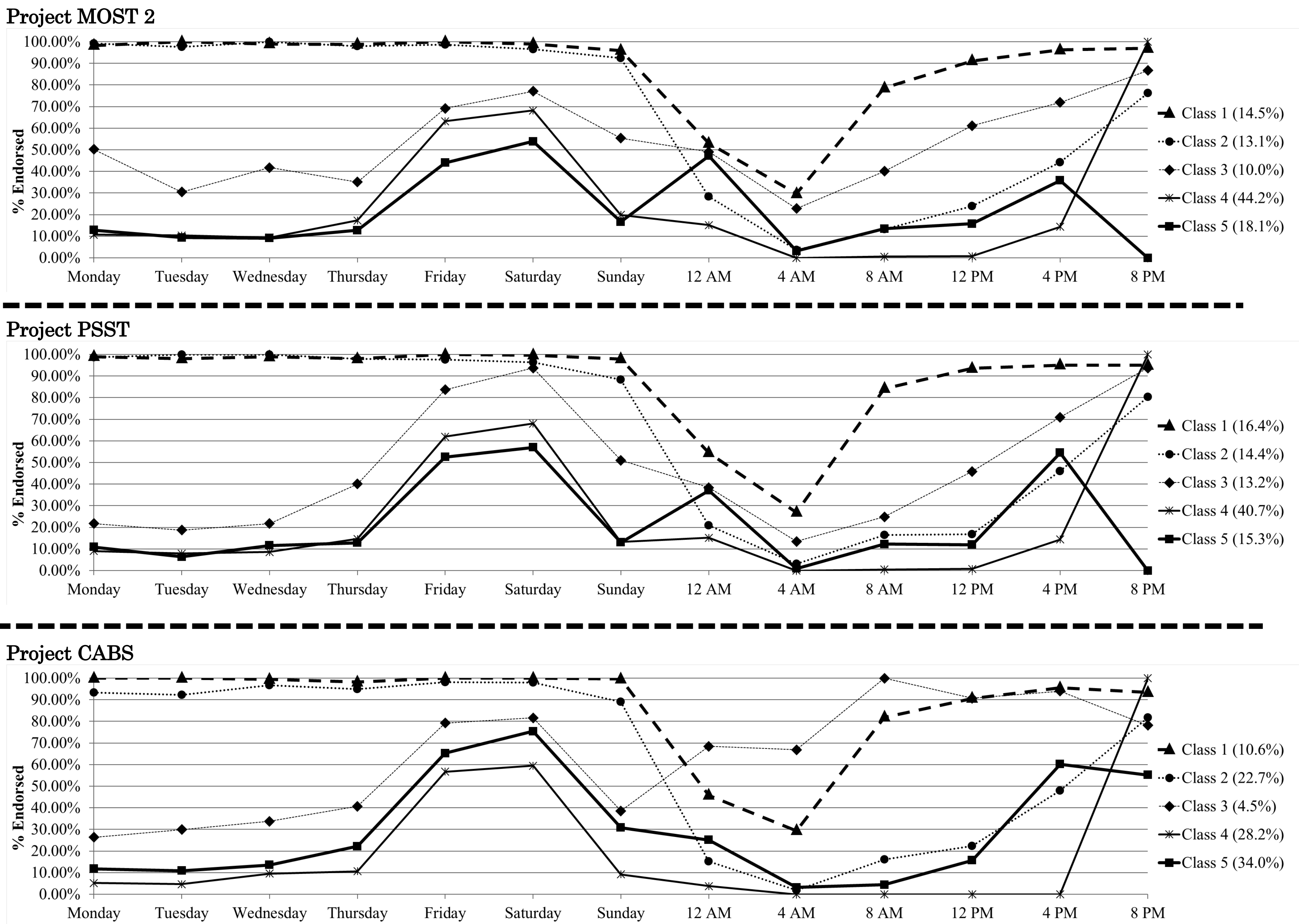

Figure 2, continued

Fridays and Saturdays (*weekend-morning*, class 3: range across datasets = 69.2-93.7%, mean across datasets = 80.4%; *weekend-night*, class 4: range across datasets = 62.0-75.4%, mean across datasets = 66.9%; *Weekend-evening*, class 5: range across datasets = 41.7-59.5%, mean across datasets = 51.5%) and less than 56% of the time on all other days of the week (*weekend-morning*, class 3: range across datasets = 18.7-55.4%, mean across datasets = 37.1%; *weekend-night*, class 4: range across datasets = 7.9-30.8%, mean across datasets = 14.25%; *weekend-evening*, class 5: range across datasets = 4.7-16.7%, mean across datasets = 11.0%). The *weekend-morning* class 3 endorsed greater morning cannabis use (between 8am-12pm) compared to the other weekend classes (*weekend-morning*, class 3: range across datasets = 24.9-100%, mean across datasets = 51.5%; *weekend-night*, class 4: range across datasets = 0.5-4.4%, mean across datasets = 1.6%; *weekend-evening*, class 5: range across datasets = 0.0-13.5%, mean across datasets = 9.15%). The *weekend-night* (class 4) endorsed nighttime cannabis use (between 8pm-12am) 100% of the time in all datasets (*weekend-morning*, class 3: range across datasets = 78.2-93.7%, mean across datasets = 86.1%; *weekend-night*, class 4: range across datasets = 0 [all 100%], mean across datasets = 100%; *weekend-evening*, class 5: range across datasets = 0.0-55.2%, mean across datasets = 13.8%). The *weekend-evening* (class 5) endorsed greater cannabis use in the evening (between 4-8pm: range across datasets = 35.8-60.2%, mean across datasets = 41.54%) than they did at night (between 8pm-12am: range across datasets = 0.0-55.2%, mean across datasets = 13.8%), whereas no other class showed decreased endorsement in these time periods. Thus, the classes are labeled to describe their defining characteristics relative to the other classes. The classes are not labeled to provide a holistic description of their characteristics and should not be interpreted as such.

Auxiliary Tests Comparing Latent Classes on Outcomes

Equality of mean comparisons using the BCH method across classes and within specific samples are reported in Table 3. For brevity, we provide overall summaries of findings across datasets as opposed to specific findings within each dataset (see Table 3 for those specific findings). Further, we only discuss differences that were statistically significant. All other findings were inconclusive as to whether or not a mean difference was present across specific classes.

Cannabis Use Disorder Symptoms and Negative Consequences

The *daily-morning* class (class 1) tended to show significantly higher scores compared to other classes on the CUDIT-R. The *daily-non-morning* class (class 2) tended to score significantly higher on the CUDIT-R than all the weekend classes. The *weekend-morning* class (class 3) tended to score significantly higher on the CUDIT-R than *weekend-night* (class 4) and *weekend-evening* (class 5) classes. Regarding cannabis-related negative consequences, the *daily-morning* class (class 1) tended to show significantly higher negative consequences on the Marijuana Consequences Questionnaire compared to other classes. The *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes reported higher negative consequences than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

Cannabis Use

For typical frequency of cannabis use, the *daily-morning* class (class 1) tended to report significantly higher frequency of use than all other classes. The *daily-non-morning* class (class 2) tended to endorse significantly higher frequency of use than all the weekend classes. The *weekend-morning* class (class 3) tended to endorse significantly higher frequency of use than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. The *weekend-night* class (class 4) tended to endorse significantly higher frequency of use than the *weekend-evening* class (class 5). For typical quantity of cannabis use, measured by the MUG, the *daily-morning* class (class 1) tended to report significantly higher quantity of use than all other classes. Further, the *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes endorsed significantly higher quantity of use than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

Table 3. *Auxiliary outcome variable means compared within datasets*

		Dataset	Daily Morning (Class 1)	Daily Non-Morning (Class 2)	Weekend Morning (Class 3)	Weekend Night (Class 4)	Weekend Evening (Class 5)	Summary of Significant Differences
Cannabis Use, Negative Consequences, Cannabis Use Disorder Symptoms	[Brief] Marijuana Consequences Questionnaire (MACQ)	*MOST 1*	14.416_{a}	10.686_{b}	12.355_{ab}	5.993_{c}	5.919_{c}	1 > 2, 4, 5 2, 3 > 4, 5
		MOST 2	6.654_{a}	5.605_{b}	4.72_{b}	2.547_{c}	2.582_{c}	1 > 2, 3, 4, 5 2, 3 > 4, 5
		PSST	6.781_{a}	4.939_{b}	4.68_{b}	1.966_{c}	2.147_{c}	1 > 2, 3, 4, 5 2, 3 > 4, 5
		CABS	7.639_{a}	5.331_{b}	4.455_{b}	1.612_{c}	2.857_{d}	1 > 2, 3, 4, 5 2, 3 > 4, 5 5 > 4
	Cannabis Use Disorder Identification Test-Revised (CUDIT-R)	*MOST 1*						
		MOST 2	13.892_{a}	12.285_{ab}	10.742_{b}	5.971_{c}	5.321_{c}	1 > 3, 4, 5 2, 3 > 4, 5
		PSST	15.416_{a}	11.864_{b}	9.824_{c}	5.204_{d}	5.764_{d}	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5
		CABS	15.793_{a}	11.421_{b}	9.197_{c}	4.435_{d}	6.604_{e}	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5 5 > 4
	Typical Frequency of Cannabis	*MOST 1*	22.621_{a}	9.563_{b}	7.196_{c}	2.301_{d}	1.478_{e}	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5 4 > 5
		MOST 2	23.873_{a}	9.627_{b}	6.86_{c}	2.202_{d}	1.509_{e}	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5 4 > 5
		PSST	24.803_{a}	9.459_{b}	7.517_{c}	1.859_{d}	1.569_{e}	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5 4 > 5
		CABS	26.265_{a}	9.057_{b}	9.768_{b}	1.269_{c}	3.18_{d}	1 > 2, 3, 4, 5 2, 3 > 4, 5 5 > 4
	Typical Quantity of Cannabis	*MOST 1*						
		MOST 2	25.037_{a}	9.209_{b}	7.635_{b}	2.135_{c}	1.728_{d}	1 > 2, 3, 4, 5 2, 3 > 4, 5 4 > 5
		PSST	26.189_{a}	9.258_{b}	7.719_{b}	2.097_{c}	1.639_{c}	1 > 2, 3, 4, 5

(Table continues)

								2, 3 > 4, 5
		CABS	20.993$_{a}$	8.242$_{b}$	10.935$_{c}$	1.073$_{d}$	3.347$_{e}$	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5 5 > 4
Cannabis Use Motives	Social Motives	*MOST 1*	3.027$_{a}$	2.725$_{b}$	3.01$_{a}$	2.611$_{b}$	2.39$_{c}$	1, 3 > 2, 4, 5 2, 4 > 5
		MOST 2	2.815$_{a}$	2.446$_{b}$	2.462$_{b}$	2.262$_{c}$	2.136$_{c}$	1 > 2, 3, 4, 5 2, 3 > 4, 5
		PSST	2.745$_{a}$	2.416$_{b}$	2.579$_{ab}$	2.236$_{c}$	2.151$_{c}$	1 > 2, 4, 5 2, 3 > 4, 5
		CABS	2.767$_{a}$	2.564$_{a}$	2.619$_{ac}$	2.134$_{b}$	2.304$_{bc}$	1, 2 > 4, 5 3 > 4
	Coping Motives	*MOST 1*	2.749$_{a}$	2.506$_{b}$	2.588$_{ab}$	1.98$_{d}$	2.022$_{d}$	1 > 2, 4, 5 2, 3 > 4, 5
		MOST 2	2.611$_{a}$	2.572$_{a}$	2.172$_{b}$	1.909$_{c}$	1.836$_{c}$	1, 2 > 3, 4, 5 3 > 4, 5
		PSST	2.53$_{a}$	2.397$_{a}$	2.412$_{a}$	1.853$_{b}$	1.861$_{b}$	1, 2, 3 > 4, 5
		CABS	3.204$_{a}$	2.841$_{b}$	2.409$_{c}$	1.787$_{d}$	2.165$_{c}$	1 > 2, 3, 4, 5 2 > 3, 4, 5 3, 5 > 4
	Enhancement Motives	*MOST 1*	4.071$_{a}$	3.898$_{b}$	3.813$_{b}$	3.61$_{c}$	3.31$_{d}$	1 > 2, 3, 4, 5 2, 3 > 4, 5 4 > 5
		MOST 2	3.896$_{a}$	3.721$_{a}$	3.438$_{b}$	3.292$_{b}$	3.058$_{c}$	1, 2 > 3, 4, 5 3, 4 > 5
		PSST	4.012$_{a}$	3.719$_{b}$	3.778$_{b}$	3.299$_{c}$	3.208$_{c}$	1 > 2, 3, 4, 5 2, 3 > 4, 5
		CABS	4.115$_{a}$	4.144$_{a}$	3.906$_{ac}$	3.304$_{b}$	3.676$_{c}$	1, 2 > 4, 5 3 > 4 5 > 4
	Conformity Motives	*MOST 1*	1.489$_{ab}$	1.382$_{b}$	1.663$_{a}$	1.447$_{b}$	1.559$_{a}$	2, 4 > 3, 5
		MOST 2	1.461$_{a}$	1.383$_{a}$	1.469$_{a}$	1.357$_{a}$	1.411$_{a}$	None
		PSST	1.363$_{ab}$	1.325$_{ab}$	1.459$_{a}$	1.307$_{b}$	1.39$_{ab}$	3 > 4
		CABS	1.263$_{a}$	1.388$_{ab}$	1.451$_{ab}$	1.315$_{ab}$	1.425$_{b}$	1 > 5
	Expansion Motives	*MOST 1*	3.129$_{a}$	2.902$_{ab}$	2.816$_{b}$	2.189$_{c}$	2.122$_{c}$	1 > 3, 4, 5 2, 3 > 4, 5
		MOST 2	3.17$_{a}$	2.734$_{b}$	2.556$_{b}$	2.044$_{c}$	2.065$_{c}$	1 > 2, 3, 4, 5 2, 3 > 4, 5
		PSST	3.004$_{a}$	2.751$_{b}$	2.847$_{ab}$	2.036$_{c}$	2.098$_{c}$	1 > 2, 4, 5 2, 3 > 4, 5
		CABS	2.976$_{a}$	2.787$_{a}$	2.646$_{a}$	1.697$_{b}$	2.203$_{c}$	1, 2, 3 > 4, 5 5 > 4

(Table continues)

Cannabis Use Norms	Injunctive Norms: Best Friends	*MOST 1*	6.112_a	5.857_b	5.387_c	5.101_d	5.041_d	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5
		MOST 2	6.116_a	5.819_a	5.385_b	5.122_{bc}	4.949_c	1, 2 > 3, 4, 5 3 > 5
		PSST						
		CABS						
	Injunctive Norms: Typical College Student	*MOST 1*	5.335_a	5.321_a	5.085_a	5.205_a	5.154_a	None
		MOST 2	5.264_a	5.357_a	5.171_a	5.128_a	5.197_a	None
		PSST						
		CABS						
	Injunctive Norms: Parents	*MOST 1*	3.228_a	2.726_b	2.845_b	2.189_c	2.187_c	1 > 2, 3, 4, 5 2, 3 > 4, 5
		MOST 2	3.343_a	3.152_a	3.067_a	2.392_b	2.147_b	1, 2, 3 > 4, 5
		PSST						
		CABS						
	Perceived Importance of Marijuana to the College Experience Scale (PIMCES)	*MOST 1*	2.931_a	2.797_b	2.759_b	2.476_c	2.446_c	1 > 2, 3, 4, 5 2, 3 > 4, 5
		MOST 2						
		PSST	2.773_a	2.488_{bc}	2.62_b	2.374_c	2.296_c	1 > 2, 3, 4, 5 3 > 4, 5
		CABS						
Other Constructs	Protective Behavioral Strategies for Marijuana (PBSM)	*MOST 1*	3.125_a	3.679_b	3.757_b	4.502_c	4.396_c	1 < 2, 3, 4, 5 2, 3 < 4, 5
		MOST 2	3.272_a	3.767_b	4.222_c	4.748_d	4.718_d	1 < 2, 3, 4, 5 2 < 3, 4, 5 3 < 4, 5
		PSST	3.265_a	3.821_b	4.217_c	4.844_d	4.753_d	1 < 2, 3, 4, 5 2 < 3, 4, 5 3 < 4, 5
		CABS						
	Marijuana Identity	*MOST 1*	3.956_a	3.231_b	2.532_c	1.704_d	1.691_d	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5
		MOST 2	3.793_a	3.27_b	2.717_c	1.814_d	1.774_d	1 > 2, 3, 4, 5 2 > 3, 4, 5 3 > 4, 5
		PSST						
		CABS						

Cannabis Use Motives

For social motives, the *daily-morning* class (class 1) tended to score significantly higher than all other classes, except the *weekend-morning* class (class 3) where differences were inconclusive. The *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes tended to score significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

For coping motives, the *daily-morning* (class 1) classes showed significantly higher scores compared to the *daily-non-morning* (class 2) classes and the *weekend-morning* (class 3) classes in 2 out of 4 datasets. The *daily-non-morning* (class 2) classes showed significantly higher scores than the *weekend-morning* (class 3) classes on 2 out of 4 datasets. The *weekend-morning* (class 3) classes tended to show significantly higher scores than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

For enhancement motives, the *daily-morning* class (class 1) tended to score significantly higher than other classes (differences were inconclusive compared to *daily-non-morning* class [class 2] in 2 out of 4 datasets). The *daily-non-morning* class (class 2) tended to score significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. In 2 out of 4 datasets, the *weekend-morning* (class 3) class was significantly higher than both the *weekend-night* (class 4) and *weekend-evening* (class 5) classes; the *weekend-night* (class 4) class scored significantly higher than the *weekend-evening* class (class 5).

For expansion motives, the *daily-morning* class (class 1) scored significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes, and scored significantly higher than the *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes in 2 out of 4 datasets. The *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes scored significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. Finally, for conformity motives, all classes across datasets showed inconclusive differences.

Cannabis Use Norms

Regarding participant's best friends, the daily classes were significantly different in one (MOST 1) out of two available datasets (MOST 1 and 2), and each reported higher injunctive norms (i.e., higher approval by best friends) than all weekend classes. The *weekend-morning* class (class 3) showed significantly higher injunctive norms scores compared to the *weekend-evening* class (class 5). For injunctive norms regarding the typical college student, differences were inconclusive among classes on both of the two available datasets (MOST 1 and 2). For injunctive norms regarding parents, in one (MOST 1) out of two datasets (MOST 1 and 2) the *daily-morning* class (class 1) showed significantly higher scores than all other classes, and the *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes scored significantly greater than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. In the MOST 2 dataset, the daily classes and the *weekend-morning* class (class 3) scored significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. For marijuana internalized norms, the *daily-morning* class (class 1) scored significantly higher than the other classes, indicating that they perceived marijuana use to be more integral to the college experience (i.e., internalized norms). The *weekend-morning* class (class 3) scored significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

Cannabis Identity and Protective Behavioral Strategies

For the cannabis user identity scale (Shadel & Mermelstein, 1996), assessing the extent to which individuals identify as a cannabis user, the *daily-morning* class (class 1) scored significantly higher than the other classes. The *daily-non-morning* class (class 2) scored significantly higher than the weekend classes. Finally, the *weekend-morning* class (class 3) scored significantly higher than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes. Regarding marijuana protective behavioral strategies, the *daily-morning* class (class 1) reported scores significantly lower than the other classes (i.e., engaged in fewer harm reduction strategies). The *daily-non-morning* class (class 2) scored significantly lower than the weekend classes. The *weekend-morning* (class 3) classes scored significantly lower than the *weekend-night* (class 4) and *weekend-evening* (class 5) classes.

DISCUSSION

The present study identified five distinct latent classes of cannabis use patterns across four independent samples based on timing of use (i.e., day of week and hour of day). The classes were compared on indicators of cannabis use, use-related negative outcomes, motives for using, use of protective behavioral strategies, perceptions, and norms associated with use. Visually (see Figure 2), the classes emerged intuitively and mostly in line with our primary hypothesis, such that they differed on morning vs. non-morning use and weekend vs. weekday use. It is important to note that the classes are labeled to describe their defining characteristics relative to the other classes, and not to provide a holistic description of their characteristics. For example, there were some individuals in the *daily-morning* class (class 1) who did not endorse use in the mornings between 8am-12pm (i.e., averaged across datasets, 18.4% assigned to this class did not endorse use during this time). We labeled it *daily-morning* because it showed far greater endorsement of morning use relative to the other daily use classes, and this should not be interpreted to mean all individuals probabilistically assigned to this class endorsed morning use. What the label *daily-morning* is referring to is that individuals assigned to that class were more likely to endorse morning use relative to daily-using individuals not assigned to that class. In other words, any of the classes labeled as 'morning' classes should not be interpreted to be assessing the 'effects of morning use,' as those classes also endorsed use throughout the day. Rather, differences between classes on the auxiliary variables may be partially explained by these differences in timing of use that are being highlighted. With this in mind, it is possible that, for example, some individuals in the *weekend-morning* class (class 3) are primarily using in the mornings on weekdays and not weekends, despite endorsing more use on the weekends and between 8am-12pm compared to the other classes.

With regard to the auxiliary variables, morning and daily cannabis use classes reported lower use of protective behavioral strategies and greater scores on indicators of use, motives, related negative consequences, and perceptions/norms compared to weekend non-morning use classes. In summary, all classes in all datasets that used in the morning or daily tended to report significantly higher scores (and lower use of protective behavioral strategies) than classes that did not use daily or in the morning. The *weekend-night* (class 4) and *weekend-evening* (class 5) classes (i.e., classes that did not use daily or in the morning) were routinely the lowest scoring classes (highest scoring for protective behavioral strategies). These results make sense intuitively and support the hypothesis that daily and morning use of cannabis are both associated with greater risks related to the auxiliary variables.

It is theoretically coherent, and evident in the results of the present study, that classes characterized by both risk-associated factors (morning and daily use) generally report higher risk related to cannabis use than other classes. Further, classes characterized by one risk-associated factor only (*daily-non-morning* [class 2] and *weekend-morning* [class 3]) scored similarly, but still greater than classes characterized by neither risk-associated factor (*weekend-night* [class 4] and *weekend-evening* [class 5]). Though causal claims cannot be made due to the cross-sectional nature of the study, differences in classes on morning vs. nighttime use in these analyses appear to be comparable to (though less impactful in magnitude) daily vs. weekend use as a risk-associated factor for intensifying cannabis use, variables related to use, and the experience of negative consequences. Theoretically, this may be because morning use makes additional use later in the day more likely to combat the 'come down'. Further, consumption in the morning may cloud judgment or decision-making and increase the likelihood of using, or generally behaving, in riskier ways. It could also be the case that morning use/timing of use is associated with other indicators related to outcomes, for example social use vs. use while alone. It may be that individuals using more often in the mornings are using more often on their own, and this may partially account for the generally more severe consequences observed. Future research should explicitly examine via longitudinal and experimental analyses if and how it may be the case that morning vs. nighttime use confers unique risks not explained by daily vs. weekend use or frequency of use more generally.

Clinical Implications

Importantly, in two of three datasets that contained data on individuals' experience of cannabis use disorder (CUD) symptoms, there were significant differences in the experience of these symptoms by class. Specifically, the pattern of symptoms from highest to lowest was as follows: *daily-morning* (class 1) → *daily-non-morning* (class 2) → *weekend-morning* (class 3) → *weekend-night* (class 4) and *weekend evening* (class 5). Broadly, for the other auxiliary variables associated with use (i.e., not the CUDIT-R), the same pattern was found, except differences between *daily-non-morning* (class 2) and *weekend-morning* (class 3) classes were inconclusive. These findings may reflect the relative strength of association between daily vs. non-daily and common vs. uncommon morning use with cannabis-related outcomes. The present study supports the idea that daily use (i.e., more frequent use) may be a key risk factor compared to morning use, given that both daily use classes displayed generally higher risk of negative consequences regardless of morning use habits. After frequency of use is accounted for, morning vs. uncommon morning use remains a useful indicator for predicting the experience of CUD symptoms and other outcomes. This interpretation is consistent with the results of Earleywine and colleagues (2016), who found that morning use accounted for unique variance in cannabis-associated problems. The results of the present study indicate that it may be useful for clinicians to consider emphasizing reducing *both* daily and morning recreational cannabis use, especially given that harm reduction interventions on these specific types of use habits can be relatively straightforward (Earleywine et al., 2016).

A recent meta-analysis found that, compared to other motives, coping motives' relations with negative outcomes were the strongest and most reliable, and coping motives were the only factor to emerge as a significant positive predictor of cannabis use frequency as well as problems (Bresin & Mekawi, 2019). In the present study, both daily use classes reported significantly greater coping motives for using cannabis compared to the weekend use classes (for 2/4 datasets; in the other 2/4 datasets, *daily-non-morning* (class 2) and *weekend-morning* (class 3) did not differ significantly). These results are consistent with the findings of Buckner and colleagues (2019), such that weekday, but not weekend, coping motives significantly predicted frequency of cannabis use and associated problems. The present study implies that individuals using cannabis daily and in the morning are using to cope more often than those who do not use daily or in the morning, and this corresponds with greater frequency, more problems experienced, and greater risk of developing CUD symptoms. Additionally, the results of two recent meta-analyses found a medium sized correlation (14% shared variance) between cannabis use frequency and related problems (Bresin & Mekawi, 2019; Pearson, 2019). The authors suggest that additional risk factors need be identified to explain how (processes) and when (diagnostic criteria) cannabis use becomes problematic (Bresin & Mekawi, 2019). Given the results of the present study, examining timing of use may be promising for predicting cannabis related problems (including CUD symptoms) as the legal status of cannabis, and the corresponding number of individuals who choose to use, continues to change.

Limitations and Future Research

This research has several limitations. First, given the cross-sectional approach, causal claims cannot be made about any of the classes and related auxiliary variables. In other words, daily and morning use may be a correlate rather than a cause of the differences among classes on indicators and outcomes measured. Future research should employ longitudinal and experimental designs to examine whether the effects of morning use of cannabis on negative consequences is a proxy for more frequent use, or whether it accounts for unique variance in consequences, as previous studies have suggested. Also, given the retrospective self-report nature of the data on a 'typical week' of cannabis use over the past 30-days, precise levels of use are not accounted for as they would be in a more intensive design, for example a daily diary. Thus, artefacts like potential use-sessions that crossover from a late night into an early morning (i.e., 8pm-12am → 12am-4am) may not be sufficiently accounted for and may present a limitation of the current study. Additionally, the sample includes only college students and the number of latent classes found in the present study may not be generalizable to other populations. Relatedly, there were important differences between the CABS dataset and the other 3 datasets; the *weekend-morning* class (class 3) in CABS endorsed the greatest use between the times of 12-4am, 4-8am, and 8am-12pm compared to all other classes, and maintained similar endorsement of use from 4-8pm and 8pm-12am. These patterns were not observed in the other datasets, which highlights the need for future research to examine whether these classes replicate robustly in other diverse datasets. It is also important to note that the analytic samples included relatively few individuals with medical cannabis cards, therefore this work may not generalize to individuals who use cannabis for medical reasons. Finally, the cannabis use measures employed in this study inquired about grams of flower used by participants, and therefore these results may not be generalizable to other forms of use (i.e., edibles, concentrates).

Conclusions

These preliminary results indicate that timing of use is associated with indicators of cannabis use and are related to the experience of negative consequences, including CUD symptoms. Recreational daily use as well as morning use may be associated with greater negative consequences, and there is evidence that most college students who use cannabis do avoid these types of use. Probing the relations between timing of cannabis use and the experience of negative consequences further and in different populations may prove a fruitful line of research for understanding the consequences of cannabis use, as well as developing effective harm reduction techniques.

REFERENCES

Adamson, S. J., Kay-Lambkin, F. J., Baker, A. L., Lewin, T. J., Thornton, L., Kelly, B. J., & Sellman, J. D. (2010). An improved brief measure of cannabis misuse: The Cannabis Use Disorders Identification Test-Revised (CUDIT-R). *Drug and Alcohol Dependence*, *110*, 137-143.

Akaike, H. (1973). Information theory and an extension of the maximum likelihood principle. In B. N. Petrov & F. Casaki (Eds.), *Second international symposium on information theory* (pp. 267–281). Budapest: Academiai Kiado.

Akaike, H. (1974). A new look at the statistical model identification. *Automatic Control, IEEE Transactions on, 19*, 716–723.

Arria, A. M., Caldeira, K. M., Bugbee, B. A., Vincent, K. B., & O'Grady, K. E. (2015). The academic consequences of marijuana use during college. *Psychology of Addictive Behaviors*, *29*, 564-575.

Asparouhov, T., & Muthén, B. (2007). Computationally efficient estimation of multilevel high-dimensional latent variable models. Proceedings of the 2007 joint statistical meetings, section on statistics in epidemiology, 2531–2535. Alexandria: American Statistical Association.

Asparouhov, T., & Muthén, B. (2015). Auxiliary variables in mixture modeling: using the BCH method in Mplus to estimate a distal outcome model and an arbitrary secondary model. *Mplus Web Notes, 21*(2).

Bakk, Z., & Vermunt, J. K. (2016). Robustness of stepwise latent class modeling with continuous distal outcomes. *Structural Equation Modeling: A Multidisciplinary Journal, 23*, 20–31.

Beresford, T. P., Blow, F. C., Singer, K., Hill, E., & Lucey, M. R. (1990). Comparison of CAGE questionnaire and computer-assisted laboratory profiles in screening for covert alcoholism. *The Lancet, 336*, 482-485.

Bravo, A. J., Pearson, M. R., Conner, B. T., & Parnes, J. E. (2017). Is 4/20 an Event-Specific Marijuana Holiday? A Daily Diary Investigation of Marijuana Use and Consequences Among College Students. *Journal of Studies on Alcohol and Drugs, 78*, 134–139.

Bravo, A. J., Prince, M. A., Pilatti, A., Mezquita, L., Keough, M. T., Hogarth, L., & Cross-Cultural Addictions Study Team. (2021). Young adult concurrent use and simultaneous use of alcohol and marijuana: A cross-national examination among college students in seven countries. *Addictive Behaviors Reports, 14*, 100373.

Bravo, A. J., Villarosa-Hurlocker, M. C., Pearson, M. R., & Protective Strategies Study Team. (2018). College student mental health: An evaluation of the DSM–5 self-rated Level 1 cross-cutting symptom measure. *Psychological Assessment, 30*, 1382–1389.

Bresin, K., & Mekawi, Y. (2019). Do marijuana use motives matter? Meta-analytic associations with marijuana use frequency and problems. *Addictive Behaviors*, *99*, 106102.

Buckner, J. D., Walukevich, K. A., & Lewis, E. M. (2019). Cannabis use motives on weekends versus weekdays: Direct and indirect relations with cannabis use and related problems. *Addictive Behaviors, 88*, 56–60.

Cherpitel, C. J. (1999). Screening for alcohol problems in the US general population: A comparison of the CAGE and TWEAK by gender, ethnicity, and services utilization. *Journal of Studies on Alcohol, 60*, 705-711.

Clark, S.L., & Muthén, B. (2009). Relating latent class analysis results to variables not included in the analysis. Available from http://www.statmodel.com/download/relatinglca.pd.

D'Souza, D. C., Radhakrishnan, R., Sherif, M., Cortes-Briones, J., Cahill, J., Gupta, S., Skosnik, P. D., & Ranganathan, M. (2016). Cannabinoids and psychosis. *Current Pharmaceutical Design, 22*, 6380-6391.

Earleywine, M., Luba, R., Slavin, M. N., Farmer, S., & Loflin, M. (2016). Don't wake and bake: Morning use predicts cannabis problems. *Addiction Research & Theory, 24*, 426-430.

Epler, A. J., Tomko, R. L., Piasecki, T. M., Wood, P. K., Sher, K. J., Shiffman, S., & Heath, A. C. (2014). Does hangover influence the time to next drink? An investigation using ecological momentary assessment. *Alcoholism: Clinical and Experimental Research, 38*, 1461-1469.

Gorelick, D. A., Goodwin, R. S., Schwilke, E., Schwope, D. M., Darwin, W. D., Kelly, D. L., McMahon, R. P., Liu, F., Ortemann-Renon, C., Bonnet, D., & Huestis, M. A. (2013). Tolerance to effects of high-dose oral Δ9-tetrahydrocannabinol and plasma cannabinoid concentrations in male daily cannabis smokers. *Journal of Analytical Toxicology, 37*, 11-16.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K. O. (1991). The Fagerström test for nicotine dependence: A revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction, 86*, 1119-1127.

Homel, J., Thompson, K., & Leadbeater, B. (2014). Trajectories of marijuana use in youth ages 15–25: Implications for postsecondary education experiences. *Journal of Studies on Alcohol and Drugs*, *75*, 674-683.

Kimbrel, N. A., Meyer, E. C., DeBeer, B. B., Gulliver, S. B., & Morissette, S. B. (2018). The impact of cannabis use disorder on suicidal and nonsuicidal self-injury in Iraq/Afghanistan-era veterans with and without mental health disorders. *Suicide and Life-Threatening Behavior, 48*, 140-148.

Lo, Y., Mendell, N., & Rubin, D. (2001). Testing the number of components in a normal mixture. *Biometrika*, *88*, 767–778.

Marsh, H. W., Lüdtke, O., Trautwein, U., & Morin, A. J. (2009). Classical latent profile analysis of academic self-concept dimensions: Synergy of person-and variable-centered approaches to theoretical models of self-concept. *Structural Equation Modeling: A Multidisciplinary Journal, 16*, 191–225.

McHugh, M. J., McGorry, P. D., Yung, A. R., Lin, A., Wood, S. J., Hartmann, J. A., & Nelson, B. (2017). Cannabis-induced attenuated psychotic symptoms: Implications for prognosis in young people at ultra-high risk for psychosis. *Psychological Medicine*, *47*, 616–626.

Meier, M. H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R. S., McDonald, K., Ward, A., Poulton, R., & Moffitt, T. E. (2012). Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proceedings of the National Academy of Sciences of the United States of America, 109*(40), E2657–E2664.

Montes, K. S., Richards, D. K., Pearson, M. R., & Marijuana Outcomes Study Team. (2021). A novel approach to assess descriptive and injunctive norms for college student marijuana use. *Addictive Behaviors, 117*, 106755.

Muthén, L. K., & Muthén, B. O. (1998–2018). *Mplus user's guide* (Eighth ed.). Los Angeles: Muthén & Muthén.

Nagin, D. S. (2005). *Group-based modeling of development*. Cambridge: Harvard University Press.

National Academies of Sciences, Engineering, and Medicine. (2017). *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research*. Washington, DC: The National Academies Press.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A monte carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*, 535–569.

Olfson, M., Wall, M. M., Liu, S. M., & Blanco, C. (2018). Cannabis use and risk of prescription opioid use disorder in the United States. *The American Journal of Psychiatry, 175*, 47–53.

Pearson M. R. (2019). A meta-analytic investigation of the associations between cannabis use and cannabis-related negative consequences. *Psychology of Addictive Behaviors*, *33*, 190–196.

Pearson, M. R., Kholodkov, T., Gray, M. J., & Marijuana Outcomes Study Team. (2017). Perceived Importance of Marijuana to the College Experience Scale (PIMCES): Initial development and validation. *Journal of Studies on Alcohol and Drugs, 78*, 319-324.

Pearson, M. R., Liese, B. S., Dvorak, R. D., & Marijuana Outcomes Study Team. (2017). College student marijuana involvement: Perceptions, use, and consequences across 11 college campuses. *Addictive Behaviors*, *66*, 83-89.

Pearson, M. R., Marijuana Outcomes Study Team, & Protective Strategies Study Team. (2022). Marijuana Use Grid: A brief, comprehensive measure of marijuana use. Manuscript submitted for publication.

Pedersen, E. R., Huang, W., Dvorak, R. D., Prince, M. A., Hummer, J. F., & The Marijuana Outcomes Study Team. (2017). The Protective Behavioral Strategies for Marijuana Scale: Further examination using item response theory. *Psychology of Addictive Behaviors*, *31*, 548–559.

Pedersen, E. R., Hummer, J. F., Rinker, D. V., Traylor, Z. K., & Neighbors, C. (2016). Measuring protective behavioral strategies for marijuana use among young adults. *Journal of Studies on Alcohol and Drugs, 77*, 441-450.

Prince, M. A., & Conner, B. T. (2019). Examining links between cannabis potency and mental and physical health outcomes. *Behaviour Research and Therapy, 115*, 111-120.

Richards, D. K, Schwebel, F. J., Sotelo, M., Pearson, M. R., & Marijuana Outcomes Study Team. (2021). Self-reported symptoms of cannabis use disorder: Psychometric testing and validation. *Experimental and Clinical Psychopharmacology*, *29*, 157-165.

Roberts B. A. (2019). Legalized cannabis in Colorado emergency departments: A cautionary review of negative health and safety effects. *The Western Journal of Emergency Medicine, 20*, 557–572.

Sclove, L. S. (1987). Application of model-selection criteria to some problems in multivariate analysis. *Psychometrics, 52*, 333–343.

Shadel, W. G., & Mermelstein, R. (1996). Individual differences in self-concept among smokers attempting to quit: Validation and predictive utility of measures of the smoker self-concept and abstainer self-concept. *Annals of Behavioral Medicine, 18*, 151-156.

Simons, J., Correia, C. J., Carey, K. B., & Borsari, B. E. (1998). Validating a five-factor marijuana motives measure: Relations with use, problems, and alcohol motives. *Journal of Counseling Psychology, 45*, 265–273.

Simons, J. S., Dvorak, R. D., Merrill, J. E., & Read, J. P. (2012). Dimensions and severity of marijuana consequences: Development and validation of the Marijuana Consequences Questionnaire (MACQ). *Addictive Behaviors, 37*, 613-621.

Sokol, R. J., Martier, S. S., & Ager, J. W. (1989). The T-ACE questions: Practical prenatal detection of risk-drinking. *American Journal of Obstetrics and Gynecology, 160*, 863-870.

Testa, M., Wang, W., Derrick, J. L., Brown, W. C., & Collins, R. L. (2019). Does morning affect contribute to daily cannabis use? *Addictive Behaviors, 95*, 64–69.

Vuong, Q. (1989). Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica, 57*, 307–333.

Walden, N., & Earleywine, M. (2008). How high: quantity as a predictor of cannabis-related problems. *Harm Reduction Journal, 5*(1), 1-8.

Zeisser, C., Thompson, K., Stockwell, T., Duff, C., Chow, C., Vallance, K., Ivsins, A., Michelow, W., Marsh, D., & Lucas, P. (2012). A 'standard joint'? The role of quantity in predicting cannabis-related problems. *Addiction Research & Theory, 20*, 82–92.

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